

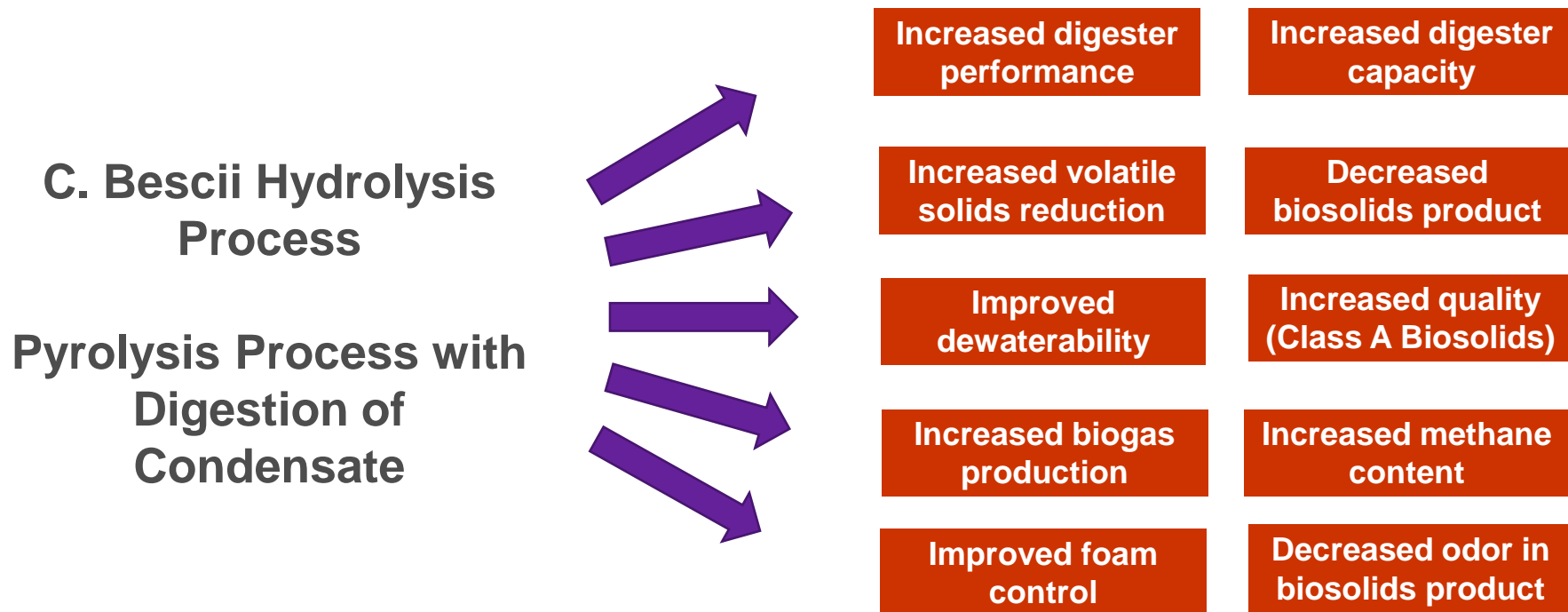


Presentation
February 2020

JACOBS

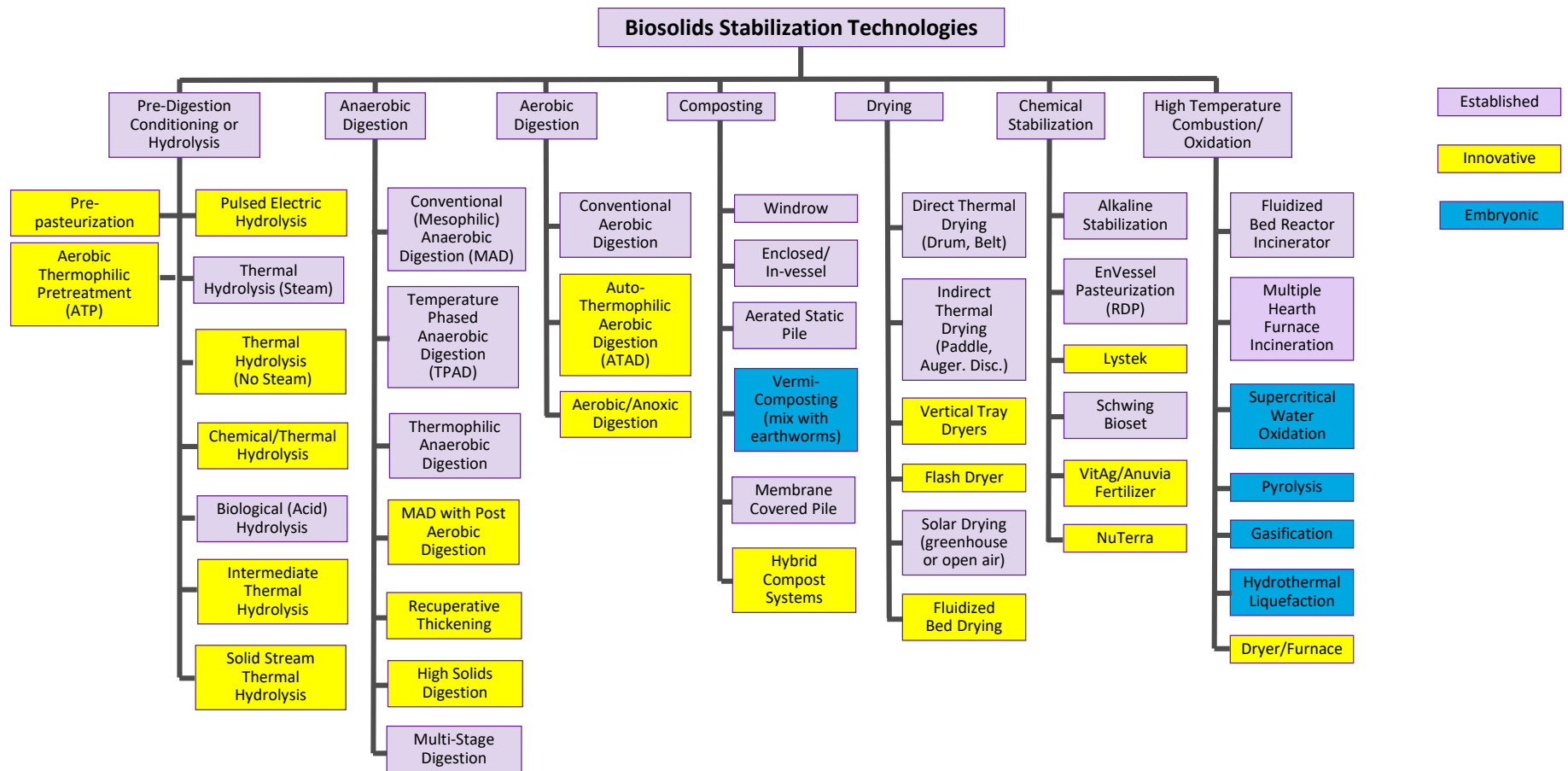
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Biological and Thermal Process Potential Benefits

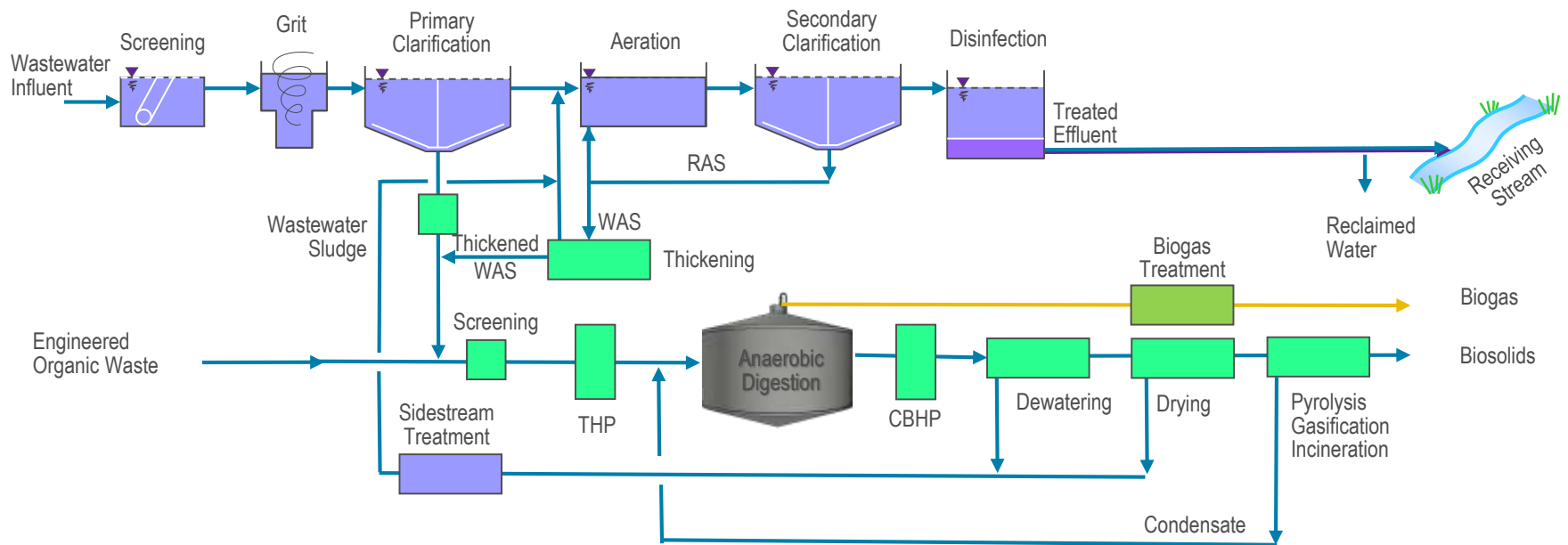


Universe of Biosolids Alternatives

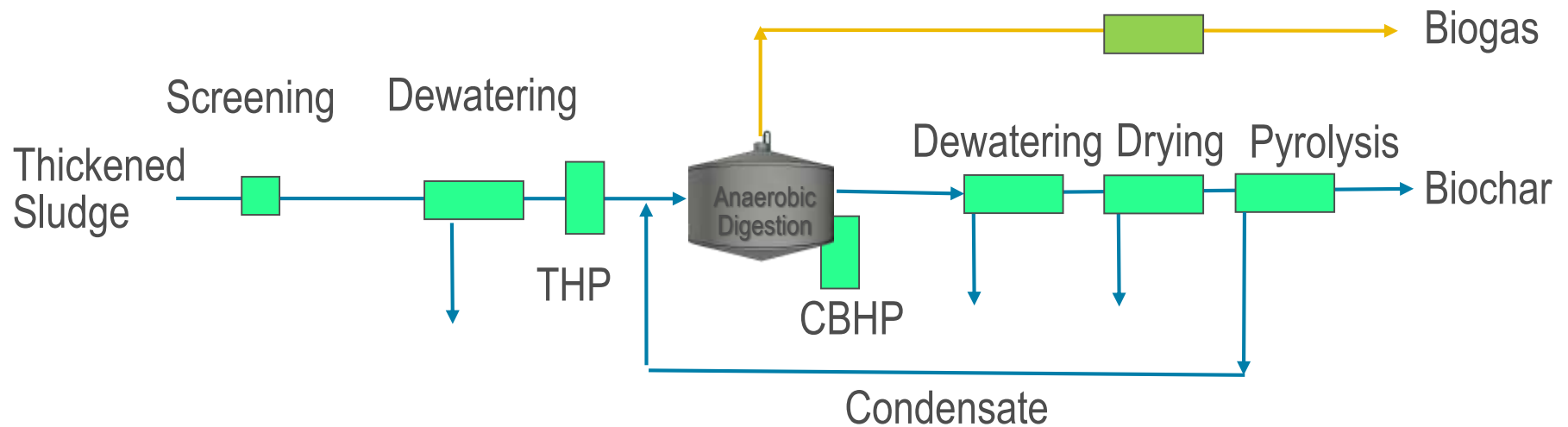
Part of Embryonic Class



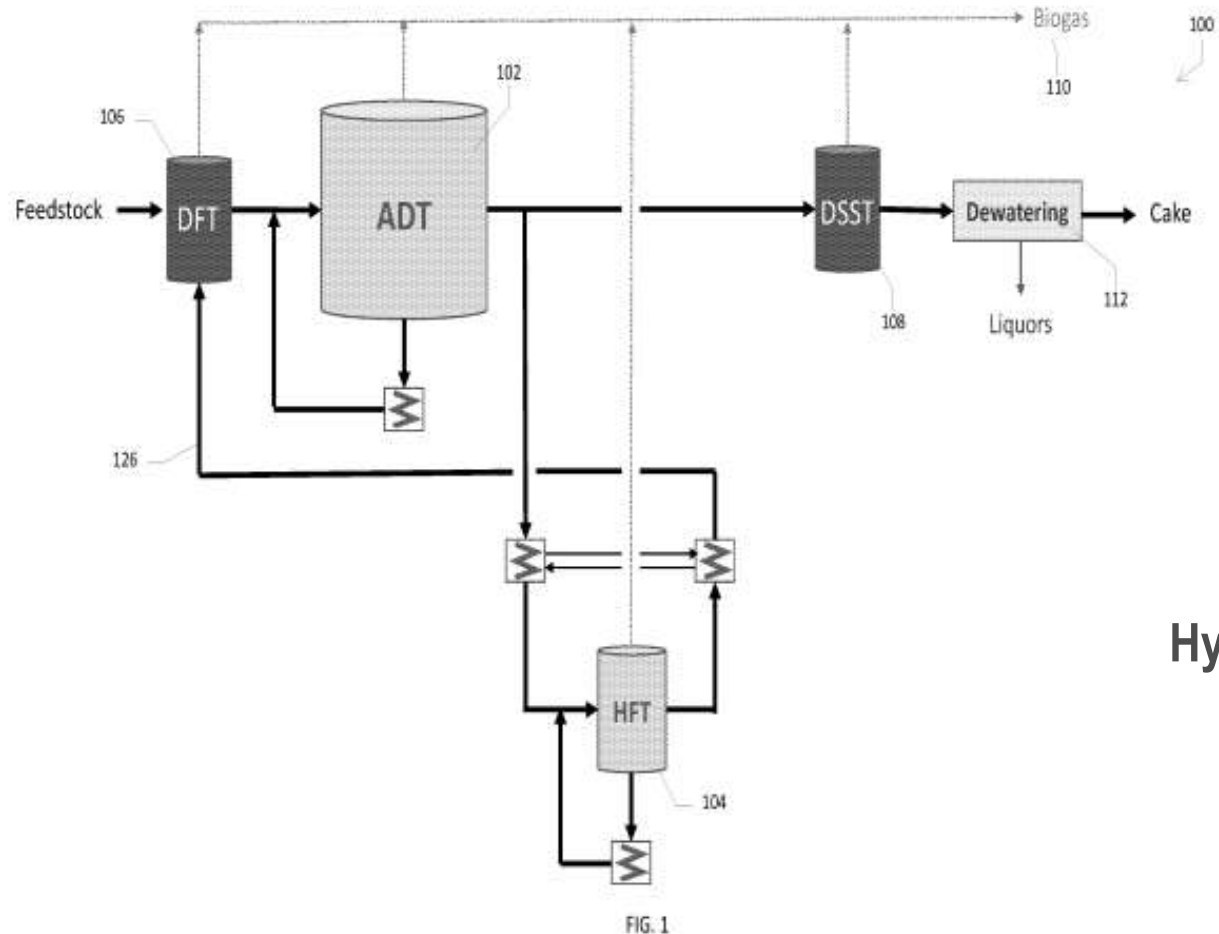
Liquid and Solids Processing



Solids Processing

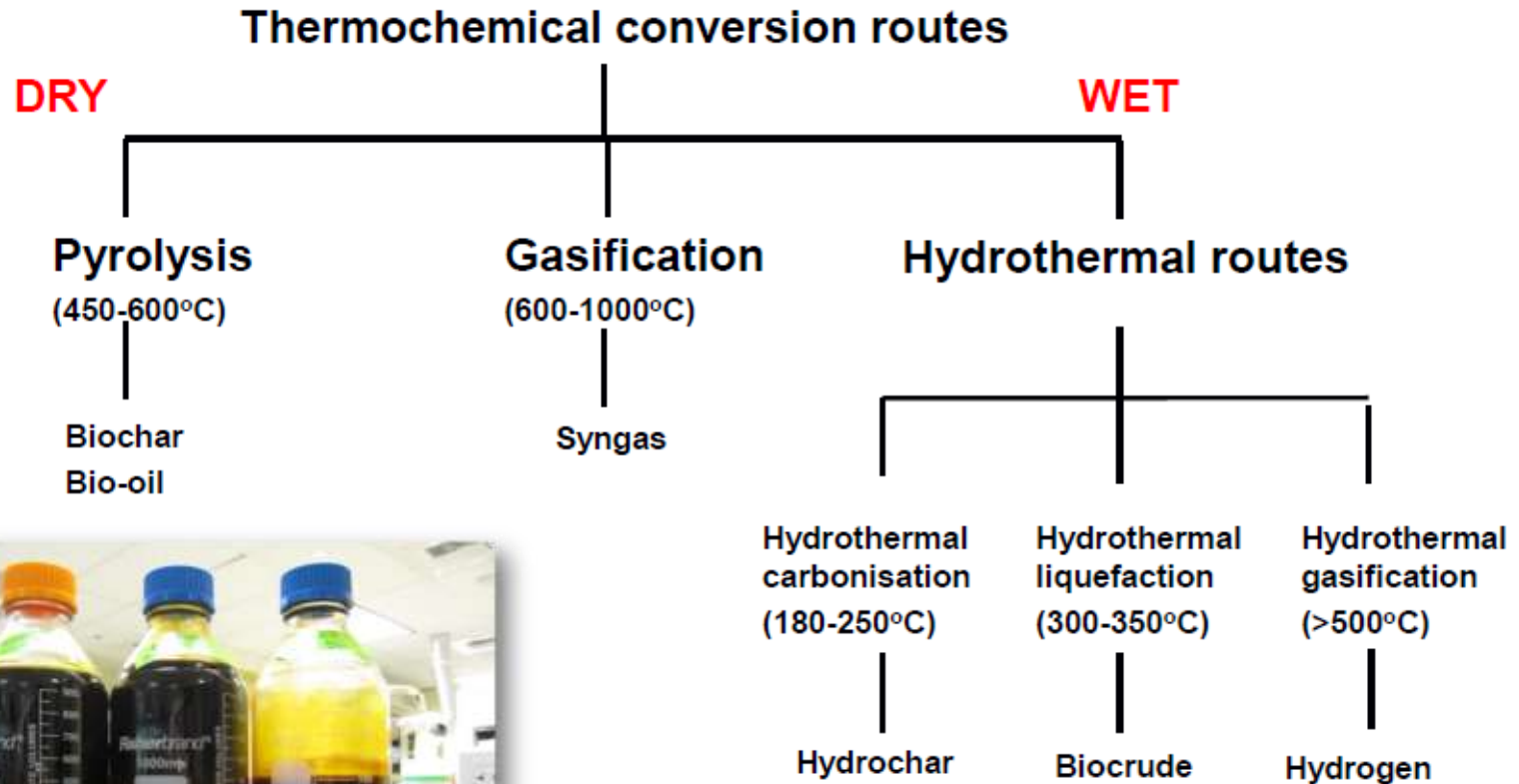


Lab Test at Gresham, Oregon



**Hydrolysis Fermentation Tank
(HFT)**
78 deg C
3-5 days
pH~7

Pyrolysis/Gasification – Thermal Conversion



Gasification Research

Pilot Plant to test syngas composition, gas cleaning, and fueling an internal combustion engine



Pyrolysis Research (PyroBioMethane)



Conversion of Biosolids to Biochar



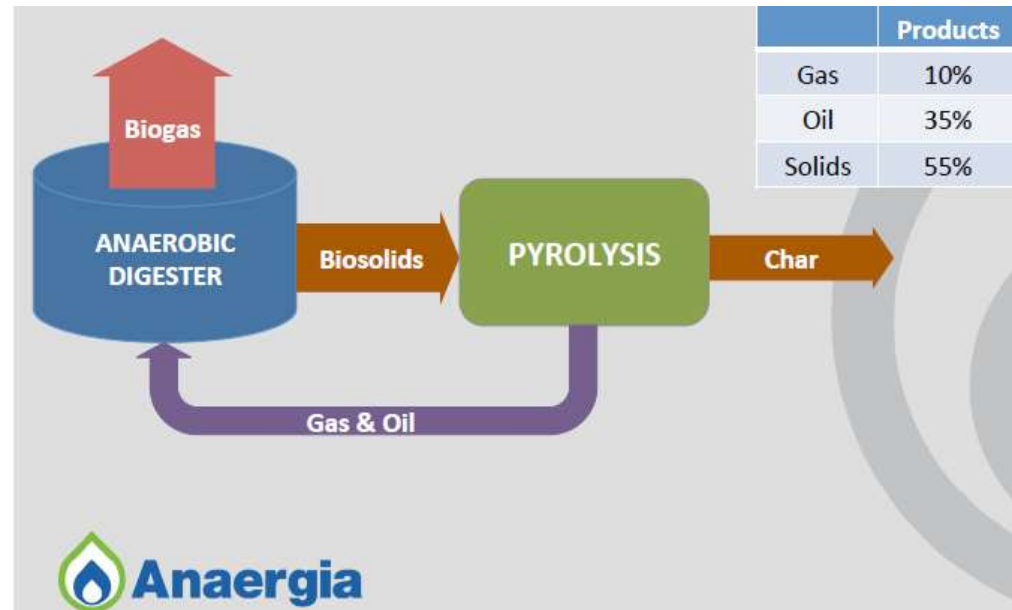
Dried Biosolid Pellets (SoundGro)



Biochar from Low Temperature Pyrolysis

Pilot: Pyrolysis of Biosolids and Digestion of Condensate

- Pilot demonstration by Anaergia at Encina WPCF
- Containerized pyrolysis unit with electric screw
- Technology installed and operated
- Processed 1,000 lb/hr of dried biosolids pellets (50% of plant production)
- Produced biochar
- Pyro oil and gas directed to Digester #5 for co-digestion with plant sludge.



Gasification/Pyrolysis Status

- North America
 - Maxwest
 - Sanford, FL – Downflow fixed bed, Fenton dryer
 - Upgraded to fluid bed, Therma-Flite dryer
 - Bankruptcy in 2014, sold technology to PHG
 - Nexterra
 - Upflow gasifier, Kamloops product development centre
 - Active in biosolids (~2010 to ~2014)
 - Pilot tested MV biosolids, Stamford, CT pellets in Kamloops
 - Changed focus in 2014 until future
 - Aries (formerly PHG Energy)
 - Downflow fixed bed (biosolids/woodwaste) and fluid bed
 - Covington, TN, developing project with Delta Diablo, CA
 - Laboratory Scale Research
 - Marquette University
 - Pacific Northwest Labs

Gasification/Pyrolysis Status

- Europe
 - Kopf- Syngas
 - Fluid Bed, gas conditioning, syngas electricity production
 - Balingen
 - Pilot and full-scale
 - Shutdown in 2014
 - Mannheim
 - Completed in 2013
 - Low production
 - Kopf refocused business away from gasification
 - Pyreg Linz-Unkel on-line in 2016 in Germany
 - UK
 - Universities and Water Companies doing research
 - Early stage of development
 - Thames Water building a 15 dt/d pyrolysis system in London using EPI Energy technology

KORE Pyrolysis and Diesel Production

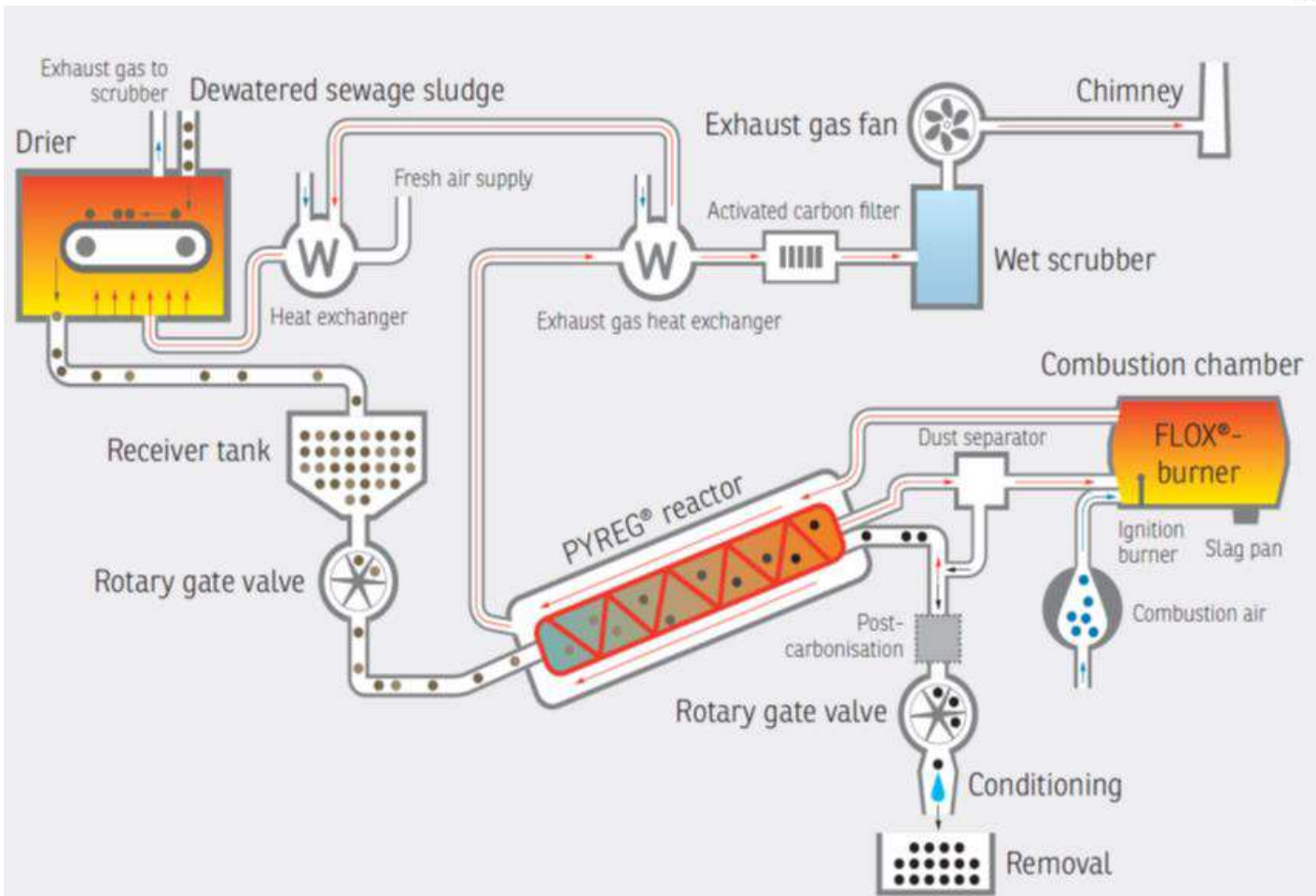
- Ran pilot at LA San Districts for 5 years
- Full scale demonstration project is under construction, on line late 2016
- Thermo chemical pyrolysis that generates a liquid fuel.
- Biochar results
- Syngas is transformed by Fischer-Tropsch process to produce advanced biofuels such as diesel
- Patented process with turnkey developers.



Pyreg[®] 3.8 dtpd facility in Linz-Unkel Germany



Pyreg[®] Pyrolysis Unit



BioForceTech Pyrolysis Unit at SVCW



PFAS Free Biochar from Bioforcetech

Biochar from Bioforcetech Corp.

One set of samples showed complete elimination of PFAS after pyrolysis at 1100°F (600°C)



| Compound Name | Dry Biosolids (ng/g) | Biochar (ng/g) |
|---------------------------------|----------------------|----------------|
| PFBA | 7.03 | Not Detected |
| 3:1 FTCA | ND | Not Detected |
| PFPeA | 5.94 | Not Detected |
| PFBS | 2.3 | Not Detected |
| 4:2 FTS | ND | Not Detected |
| PFHxA | 33.7 | Not Detected |
| PFPeS | ND | Not Detected |
| HFPO-DA | ND | Not Detected |
| 5:3 FTCA | 64.5 | Not Detected |
| PFHpA | 7.45 | Not Detected |
| ADONA | ND | Not Detected |
| PFHxS | ND | Not Detected |
| 6:2 FTS | ND | Not Detected |
| PFOA = 89.1 & PFOS = 11.3 | | 89.1 |
| | | ND |
| | | 40 |
| | | 5.3 |
| | | ND |
| | | 26.3 |
| | | ND |
| | | 11.3 |
| 8:2 FTS | 5.68 | Not Detected |
| PFNS | ND | Not Detected |
| MeFOSAA | 23.5 | Not Detected |
| EtFOSAA | 19.6 | Not Detected |
| PFUnA | 3.29 | Not Detected |
| PFDS | ND | Not Detected |
| 11CI-PF3OUdS | ND | Not Detected |
| 10:2 FTS | ND | Not Detected |
| PFDoA | 5.85 | Not Detected |
| MeFOSeA | ND | Not Detected |
| PFTeDA | ND | Not Detected |
| PFTeDA | 2.44 | Not Detected |
| EtFOSeA | ND | Not Detected |
| PFHxDA | ND | Not Detected |
| PFODA | ND | Not Detected |
| MeFOSe | 17.1 | Not Detected |
| EtFOSe | ND | Not Detected |

All ND
@
2ppb

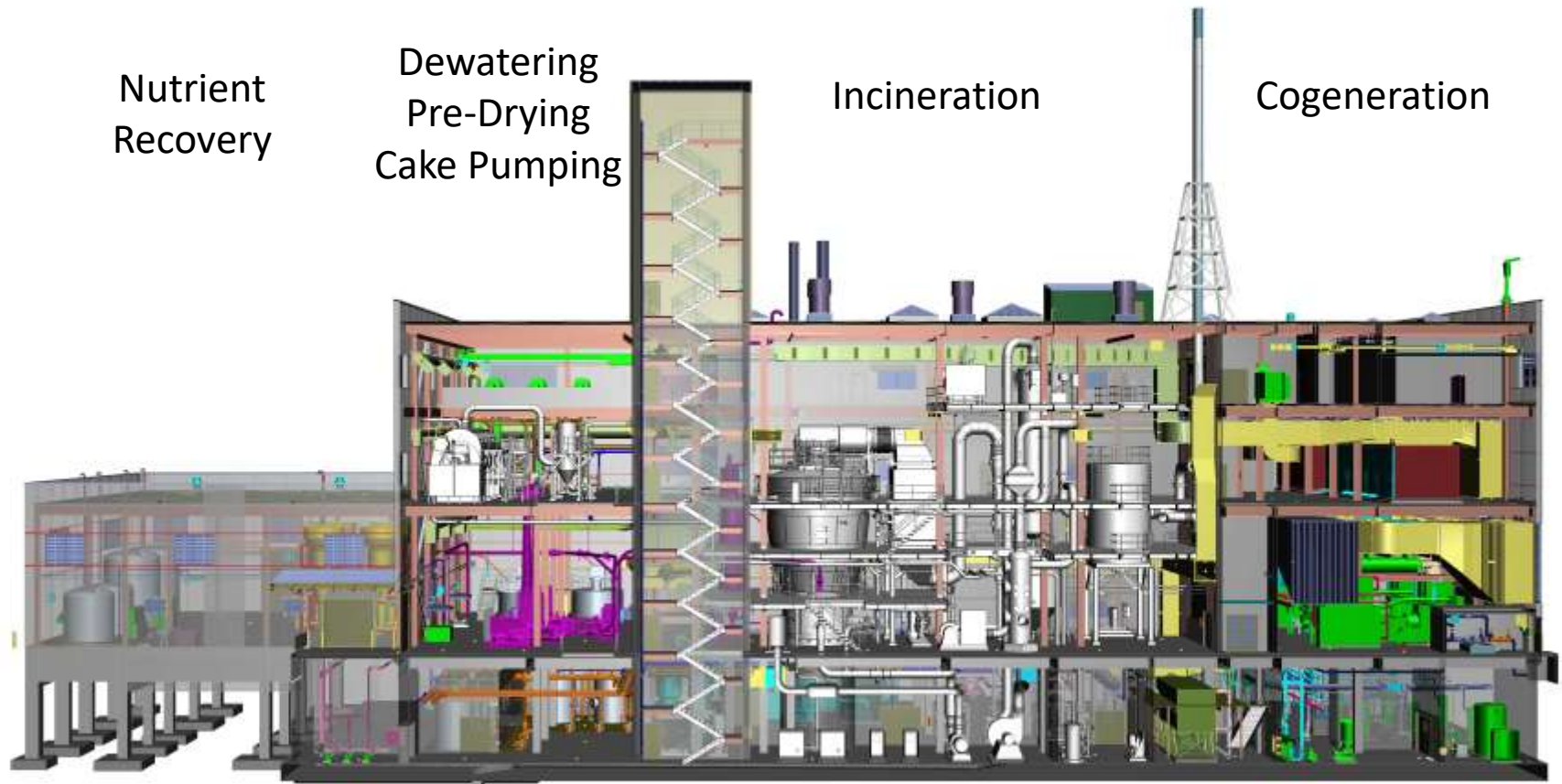
EcoRemedy Morrisville Biosolids Gasification Project



Thames Water Pyrolysis Demonstration



Green Bay's R2E2 BioThermal System with Anaerobic Digestion and Incineration



BioThermal Carbon Conversion



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